PATENT SPECIFICATION

(11) 1 602 628

1 602 628

(21) Application No. 21191/78 (22) Filed 22 May 1978

(31) Convention Application No. 2729512

(32) Filed 30 June 1977 in

(33) Federal Republic of Germany (DE)

(44) Complete Specification published 11 Nov. 1981

(51) INT CL³ F16H 39/44 B60K 41/16

(52) Index at acceptance

F2W 010 016 026 040 048 050 062 070 072 076 178 182 198 252 274 282 286 292 350 368 370 376 388 390 392 396 398 402 404 406 410 C5

(19) THE PATENT OFFICE LONDON

(72) Inventor GERHARD NONNENMACHER

(54) CONTROL DEVICE FOR A HYDROSTATIC POWER TRANSMISSION

(71) We, ROBERT BOSCH GMBH., a German company of Postfach 50,700 Stuttgarf 1, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to apparatus for controlling an hydrostatic power transmission.

Hydrostatic power transmissions are generally in the form of a main hydraulic pump and a hydraulic motor arranged to be driven by the main hydraulic pump. An auxiliary hydraulic pump is normally provided as a source of hydraulic fluid for adjusting the delivery of hydraulic fluid by the main pump to the motor, for the purpose of varying the transmission ratio of the hydrostatic power transmission. Usually, the main and auxiliary pumps are both driven by a common combustion engine.

When an Otto engine is used to drive the pumps, especially an Otto engine supplied with fuel through a carburettor, the speed of the engine will vary with the load on the engine. Thus, any setting of the valve controlling the supply of fuel to the engine will pre-select the torque delivered by the engine and not the speed of the engine. Thus, if the load on the engine decreases, its speed will increase and the hydraulic transmission will receive more power than it can use. This may result in damage to the transmission.

If, for example, the power transmission is used in combination with an Otto engine to drive a vehicle, the torque delivered by the engine to the main pump at a particular fuel supply valve setting when the vehicle is travelling uphill, may produce a pressure in the hydrostatic transmission which is high enough to damage the transmission should the vehicle change to downhill travel.

On the other hand, if the vehicle changes from downhill travel to uphill travel with the same fuel supply valve setting, the speed of the engine may fall below its stalling speed.

In accordance with the invention, apparatus is provided for controlling an hydrostatic power transmission in the form of a main hydraulic pump and an hydraulic motor arranged to be driven by the main hydraulic pump, the apparatus comprising an auxiliary hydraulic pump arranged to deliver hydraulic fluid to means for adjusting the delivery of hydraulic fluid by the main pump to the motor and a servo device arranged to adjust the fuel supply valve setting of a combustion engine for driving the main and auxiliary pumps, the auxiliary pump being arranged to deliver hydraulic fluid through a first throttle generating a first pressure-difference signal for adjusting the main pump delivery in accordance with the speed of the combustion engine and through a second throttle, in series with the first throttle, generating a second pressure-difference signal for controlling the servo device.

The second throttle is preferably arranged between the auxiliary pump and the first throttle. The second throttle may also be made adjustable and the first throttle be made non-adjustable.

Alternatively, the first and second throttles may both be made adjustable. Depending on the required hydrostatic pressure distribution of the main pump over the operational range of the combustion engine, the first and second throttles may be adjustable simultaneously, either in the same sense or in opposite senses.

A third throttle, which may also be made adjustable, can be arranged in parallel with the first throttle.

If the apparatus is mounted on a vehicle, the second throttle is preferably arranged to be actuated by the accelerator pedal of the vehicle.

The servo device is preferably in the form of a piston and cylinder, the piston of which is arranged to adjust the fuel supply valve setting of the combustion engine.

The means for adjusting the main pump delivery to the motor preferably comprise a pressure-proportional setting device under the influence of the first pressure-difference signal. In that case, the pressure-difference signal may be arranged to influence a control valve in such a manner that, when the said signal reaches a lower limit value, the control valve is actuated to provide a flow of hydraulic fluid so influencing the means for adjusting the main pump delivery, as to reduce the main pump delivery. Moreover, the said flow of hydraulic fluid may pass through a fourth throttle controlling a valve arranged in an adjustment circuit for the main pump.

The control valve is preferable a 2 position 2-way valve or a 2 position 3-way valve influenced by the second pressure-difference signal against the force of a spring.

The invention also extends to a combination of apparatus for controlling an hydrostatic transmission and an Otto engine. In that case, the Otto engine is preferably supplied with fuel through a carburettor. That combination of control apparatus and carburettor Otto engine is especially suitable for mounting on a vehicle so as to form a driving unit for the vehicle.

In order that the invention may be clearly understood and readily carried into effect, two embodiments of the apparatus in accordance with the invention and a number of modifications thereof, will now be described with reference to the accompanying drawings in which;

Figure 1 is a diagram of a first embodiment of apparatus in accordance with the invention,

Figures 2 and 3 show modifications of the throttle arrangement of Figure 1,

Figure 4 is a diagram of a second embodiment of apparatus in accordance with the invention and

Figures 5 and 6 show modifications of the throttle arrangement of Figure 4.

The apparatus shown in Figure 1 comprises a main hydraulic pump 11, which drives a hydraulic pump 12 through lines 13 and 14, and an auxiliary hydraulic pump 10 for delivering hydraulic fluid to two pressure actuated adjusting devices 15 and 16 which adjust the delivery of hydraulic fluid by the main pump 11 to the motor 12. The pump 11, motor 12 and lines 13 and 14 form a hydrostatic power transmission, the transmission ratio of which can be adjusted by means of the adjusting devices 15 and 16. In Figure 1 the line 13 is the low pressure line and the line 14 is the high pressure line.

The two adjusting devices 15 and 16 are in the form of pistons arranged in cylinders and acting on the stroke generating member (for example a stroke ring) of the pump 11. Of the two devices, the device 15 has the smaller piston area which is always subjected to pressure from the high pressure side of the power transmission. To this end, a line 17 extends from the device 15 to a line 18 connected between the lines 13 and 14. A shuttle valve 19 is arranged at the junction of the lines 17 and 18 and is operated in one sense or the other by whichever of the lines 13 and 14 is carrying the high pressure delivery fluid from the pump 11. Thus, the device 15 receives high pressure fluid from the pump 11 irrespective of the sense of operation of the pump 11 and/or the motor 12.

The pumps 10 and 11 are intended to be driven by the kind of combustion engine, for example an Otto engine, preferably supplied with fuel through a carburettor, the speed of which would normally vary with the load on the engine. The apparatus of Figure 1 is also provided with means whereby the transmission ratio of the hydrostatic transmission can be adjusted in accordance with the speed of the engine and the fuel supply to the engine can be adjusted in accordance with the load on the engine.

For this purpose, the device 16 with the larger piston area is supplied with hydraulic fluid at a controlled pressure through a line 21. The fluid at a controlled pressure is supplied through a pressure-proportional pump setting device 22 comprising a slide valve member 24 coupled by a rod 23 to the device 16 and a control unit 25. Lines 26 and 27 lead to opposite ends of the control unit 25, from a control valve 28 for controlling the sense of operation of the hydrostatic transmission. The apparatus may be used for driving a vehicle so that the sense of operation of the transmission may determine the direction of travel of the vehicle. In the pressureless state, that is to say with the valve 28 in position II, the control unit 25 is held in the neutral position by two springs 30 and 31 acting on its ends. A line 32 including a throttle 33 leads from the control unit 25 to a reservoir 34. Furthermore, a second line 35 including a throttle 36 leads from the control unit 25 to a line 37 which branches from the line 17. The line 37 leads to one end of a slide valve 38 for the low-loss pressure-limitation of the hydrostatic power transmission. From the other end of the slide valve 38, a line 39 leads to a pilot valve 40, associated with the slide valve 38, which is relieved to the reservoir 34. Another line 41 leaves the line 35 and joins the line 39. A throttle 42 is arranged in the line 41. A spring 43 acts upon the side of the slide valve 38 to which the line 39 is connected.

From one port on the inlet side of the control valve 28, a first line 45 leads to the pressure space 46 in a servo-device 47, the piston 48, the piston rod 49 of which adjusts the setting of the fuel supply valve 50 of the combustion engine (not shown). A line 51, also connected to the line 45, leads from the auxiliary pump 10 to the line 13 of the adjustable pump 11. From the line 51 a line 52 leads to the other pressure space 53 of the servo-device 47. A spring 54, which acts upon the piston 48, is arranged in the pressure space 46 of the servo-device 47. An adjustable throttle 55 is arranged in a section 51' of the line 51, which lies between the junctions of the lines 52 and 45. The throttle 55 is actuated against the force of a spring 56 by a pedal 57, which may be an accelerator pedal of a vehicle. Upon depressing the accelerator pedal, the cross-section of the throttle 55 is increased. A throttle 59 of constant cross-section is arranged in a section 51" of the line 51 which lies downstream of the point where the line 45 joins the line 51.

A line 60 leads from the line 51 to another port on the inlet side of the control valve 28, the fluid in the lines 45 and 60 being passed selectively to the unit 25 by moving the valve 28 into one or other of its I or III positions.

Thus, the apparatus comprises a first throttle 59, in this case non-adjustable, and a second throttle 55, in this case adjustable, arranged in series with the first throttle and in this instance, between the auxiliary pump 10 and the first throttle 59. The throttles 55 and 59 could be arranged in the line 51 in reverse order.

When the auxiliary pump, driven by the combustion engine, is delivering hydraulic fluid to the adjusting devices 15 and 16 for the main pump, the hydraulic fluid passes through the throttles 59 and 55. In so doing, the first throttle 59 generates a first pressure difference signal which, through the proportional pump setting device 22, adjusts the main pump delivery in accordance with the speed of the combustion engine driving the pumps 10 and 11. At the same time, the second throttle 55 generates a second pressure difference signal which is used to control the position of the piston 48 in the servo device 47 and consequently the setting of the fuel supply valve 50 of the combustion engine.

A line 61, including a non-return valve 62, branches from the line 51 and leads to the line 14. The valve 62 opens towards the line 14. A branch line 61' leads to a pressure limiting valve 63 for limiting the pressure of the hydraulic fluid delivered to the devices 15 and 16. Finally, a line 64 leads from the device 16 to a port on one side of the valve 38 and from a port on the other side of the valve 38, to the line 51.

Since the auxiliary pump 10 is driven in synchronism with, or proportionally to, the speed (r.p.m.) of the combustion engine, as the speed of the combustion engine increases, the pressure difference across the throttle 55 becomes greater, that is to say, the pressure in the line 52 rises, whereby the piston 48 is displaced towards the right against the force of the spring 54 and the pressure in the space 46, and actuates the fuel supply valve 50 in the closing direction. The strength of the spring 54 is such that, it determines the lower limit of the load-dependent proportional range of the engine when the throttle valve 50 is closed just so far that the combustion engine can still rotate against the load torque from the hydrostatic power transmission at the time. Thus, the strength of the spring 54 determines the lower speed limit of the load-dependant proportional range, that is to say, the so-called degree of irregularity of the regulating characteristic of the combustion engine.

Let it be assumed that the control valve 28 is in its switching position I. When the hydrostatic transmission is used to drive a vehicle, this corresponds to forwards travel of the vehicle. The lower end of the control unit 25 is then acted upon, through the lines 45 and 27, by the pressure in front of the throttle 59, and the upper end of the control unit 25 is acted upon, through the lines 26, 60 and 51, by the pressure beyond the throttle 59.

Let it further be assumed that the main pump 11 is delivering hydraulic fluid into the line 13 which is now the high pressure line. The high pressure also prevails in the lines 51, 17, 37, 41, 35 and 39. If the load on the motor 12 increases, the pressure in the line 13 rises and the torque on the pump 11 becomes greater. As a consequence the speed of the combustion engine and of the auxiliary pump 10 falls. The pressure drop at the throttle 55 and the pressure in the space 53 are thereby reduced. Now the spring 54 can slide the piston 48 towards the left, whereby the throttle valve 50 is opened to compensate for the fall in speed of the combustion engine. The pressure drop at the throttle 59 has also been slightly reduced, whereby the control unit 25 is displaced downwards by the spring 30. Hydraulic fluid can now flow out of the line 35 carrying the high pressure, through the slide valve member 24 and the control unit 25 into the line 21, and from there into the adjusting device 16. This sets the pump 11 to a slightly smaller stroke to compensate for the increase in torque at the pump. Through these two measures, variations in the speed of the combustion engine is held between very narrow limits.

If the load on the motor 12 is reduced, the pressure in line 13 drops and the torque at the pump 11 becomes lower. The speed of the combustion engine then increases whereby the pressure difference signals at the throttles 55 and 59 also increase. The fuel supply throttle valve closes slightly and the pump 11 is adjusted to a slightly larger stroke. This is effected by an upward movement of the control parts 25/24, whereupon a small quantity of fluid flows out of the positioning device 16 to the container 34. Through these two control signals, any increase in the speed of the combustion engine is kept within very narrow limits. The delivery pressure from the pump 11 always prevails in the positioning device 15.

As described above, the cross-section of the throttle 55 can be varied by the pedal 57. By opening the throttle 55, higher speeds of the combustion engine are pre-selected. Thereby, and in cooperation with the pressure conditions at the throttles 55 and 59, the combustion engine can be loaded at low speeds, whereby noise and fuel consumption are reduced.

If the pressure in the high pressure circuit of the hydrostatic power transmission exceeds a predetermined maximum value, the servo-valve 40 opens and the valve 38 is displaced into its throughflow position II whereupon the power transmission circuit is unloaded but is not subject to any fluid pressure loss. This is because fluid can then flow through the line 64 to the adjusting device 16 to set the pump 11 to a smaller stroke. This provides pressure limitation in the circuit free of fluid pressure loss.

Figure 2 shows a modification of the arrangement of Figure 1 in which the signal for adjusting the main pump delivery is generated by a throttle arrangement of special construction. The arrangement is designated 70 and consists of the parallel connection of a first throttle 71 of non-adjustable cross-section and a third throttle 72 of adjustable cross-section, in parallel with the throttle 71. For this purpose the line 51 is provided with two branches 73 and 74 which unite again beyond the throttles 71 and 72. The cross-section of the non-adjustable throttle 71 is smaller than the maximum cross-section of the adjustable throttle 72. With throttles which are so dimensioned, better matching is achieved of the adjustment of the pump to the power characteristic of the combustion engine employed.

A further modification of the arrangement of the throttles 55 and 59 in Figure 1 is shown in Figure 3. Once again two throttles 80 and 81 are provided in the line 51. These throttles are both adjustable and are also coupled together. They may be coupled so that the cross-section of the throttle 81 is reduced when that of the throttle 80 is increased and vice versa. That is to say, the throttles are adjustable simultaneously in opposite senses. However, both throttles may be adjustable simultaneously in the same sense. This depends, in each case, upon the required fluid pressure distribution of the main pump over the power characteristic of the combustion engine.

The apparatus shown in Figure 4 is provided with power-limiting regulation, so that the combustion engine cannot be stalled. The embodiment of Figure 4 differs from that of Figure 1 by another line 95 branching off from the line 51 from the auxiliary pump 10, and leading to one end of a slide valve 96. A line 97 leads from the other end of the valve 96 to the line 45. The slide valve 96 is a 2/2-way valve which has a line 98 connecting it to the reservoir 34 and a line 99 which leads through a throttle 100 to the line 39. All the other parts are exactly the same as in the embodiments of Figures 1 and 3.

As long as the speed of the combustion engine is that pre-selected by the pedal 57 acting on the throttle 55 or 80, the pressure difference at this throttle changes within the range prescribed by the spring 54 in the servo-device 47. On the other hand, if, due to too high a load, the combustion engine cannot respond to the position of the pedal 57, the pressure difference at the throttle 55 falls below the value established by the force of the spring 54. In that case, the power-limiting regulation becomes effective. The spring 101 forces the slide valve 96 into its switching position II, whereupon fluid can flow out of the line 99 through the throttle 100 and the slide valve 96 to the reservoir 34. In that case, a pressure drop arises at the throttle 42, which is adequate to bring the slide valve 38 into its through-flow position II and hence, as described above, to cause resetting of the main pump 11 to a lower delivery rate. This is set back until the combustion engine has again reached its prescribed speed.

In so doing, increased pressure from the pump 10 closes the slide valve 96 just sufficient to allow almost complete closure of the slide valve 38. This, in cooperation with the increased effect of the throttles 55 and 59 or 80 and 81, brings the setting of the main pump 11 into balance in an intermediate position.

Figure 5 shows a modified circuit arrangement for the power-limiting regulator of Figure 4. The line 99 is omitted, being replaced by a line 105 which leads to the line 45. Furthermore, a line 106 leads from the slide valve 96 to the line 51, and the feed pressure limiting valve 63 and the line 61 delivering into the low pressure circuit, are connected to the line 106. It is thereby achieved that the throttles 81 of the second measuring circuit become bridged across by the power limiting regulator and hence the hydropump 11 is reset.

Figure 6 corresponds essentially with Figure 4, and shows a modified power limiting regulator which has a slide valve 110 which can adopt three switching positions I, II, III. This provides a double-acting function. If, for example upon braking of a vehicle, the combustion engine speeds up, the pressure difference signal at the throttle 80 controlling the servo-device increases to a value which is not reached in normal operation. In this case, the power limiting regulator adopts the switching position III by which this speeding up of the engine is prevented. Upon reaching a braking torque which the combustion engine can no longer withstand, the pump 11 is adjusted to a greater stroke. The braking effect is thereby limited to a value which the combustion engine can accept.

WHAT WE CLAIM IS:—

1. Apparatus for controlling a hydrostatic power transmission in the form of a main hydraulic pump and a hydraulic motor arranged to be driven by the main hydraulic pump, the apparatus comprising an auxiliary hydraulic pump arranged to deliver hydraulic fluid to means for adjusting the delivery of hydraulic fluid by the main pump to the motor and a servo device arranged to adjust the fuel supply valve setting of a combustion engine for driving the main and auxiliary pumps, the auxiliary pump being arranged to deliver hydraulic fluid through a first throttle generating a first pressure-difference signal for adjusting the main pump delivery in accordance with the speed of the combustion engine and through a second throttle, in series with the first throttle, generating a second pressure-difference signal for controlling the servo device.

2. Apparatus according to claim 1, in which the second throttle is arranged between the auxiliary pump and the first throttle.

3. Apparatus according to claim 1 or claim 2, in which the second throttle is adjustable and the first throttle is non-adjustable.

4. Apparatus according to claim 1 or claim 2, in which the first and second throttles are both adjustable.

5. Apparatus according to claim 4, in which the first and second throttles are adjustable simultaneously in the same sense.

6. Apparatus according to claim 4, in which the first and second throttles are adjustable simultaneously in opposite senses.

7. Apparatus according to any one of claims 1 to 3, in which a third throttle is arranged in parallel with the first throttle.

8. Apparatus according to claim 7, in which the third throttle is adjustable.

9. Apparatus according to any preceding claim, in which the second throttle is arranged to be actuated by a vehicle accelerator pedal.

10. Apparatus according to any preceding claim, in which the servo device is in the form of a piston and cylinder, the piston of which is arranged to adjust the fuel supply valve setting of the combustion engine.

11. Apparatus according to any preceding claim, in which the means for adjusting the main pump delivery to the motor comprise a pressure-proportional setting device under the influence of the first pressure-difference signal.

12. Apparatus according to any preceding claim, in which the second pressure-difference signal is arranged to influence a control valve in such a manner that, when the said signal reaches a lower limit value, the control valve is actuated to provide a flow of hydraulic fluid so influencing the means for adjusting the main pump delivery, as to reduce the main pump delivery.

13. Apparatus according to claim 12, in which the flow of hydraulic fluid passes through a fourth throttle controlling a valve arranged in an adjustment circuit for the main pump.

14. Apparatus according to claim 12 or claim 13, in which the control valve is a 2 position 2-way valve or a 2 position 3-way valve influenced by the second pressure-difference signal against the force of a spring.

15. Apparatus for controlling a hydrostatic power transmission substantially as herein described with reference to Figure 1 or Figure 1 including one or more of the modifications of Figures 2 to 6.

16. Apparatus according to any preceding claim in combination with an Otto engine.

17. The combination according to claim

16, in which the Otto engine is supplied with fuel through a carburettor.

18. Apparatus according to claim 16 or the combination of claim 17, mounted on a vehicle to provide a driving unit for the vehicle.

A. A. THORNTON & CO.,
Chartered Patent Agents,
Northumberland House,
303/306 High Holborn,
London, WC1V 7LE.

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1981
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

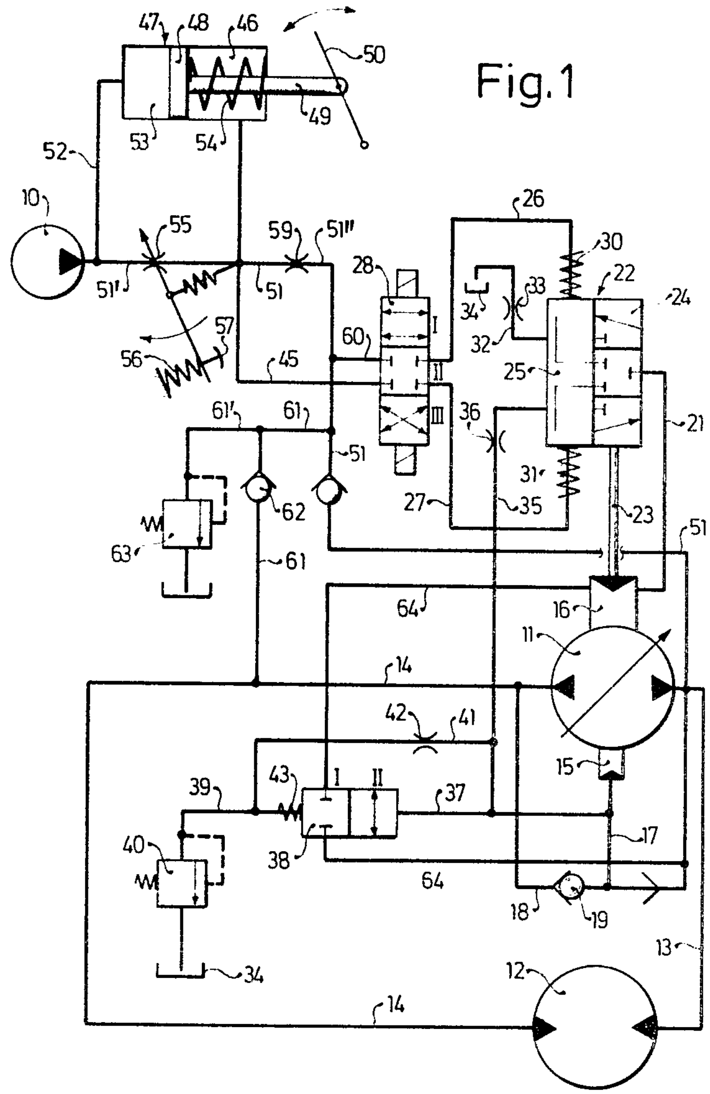

47
48
46
50
49
53
54
52
10
55
59
51''
51'
51
57
56
45
60
28
I
II
III
61'
61
62
63
26
30
22
24
34
33
32
25
36
31
21
27
35
23
51
64
16
11
14
42
41
15
39
43
I
II
37
40
38
64
17
18
19
13
34
12
14

Fig.1

Fig. 2

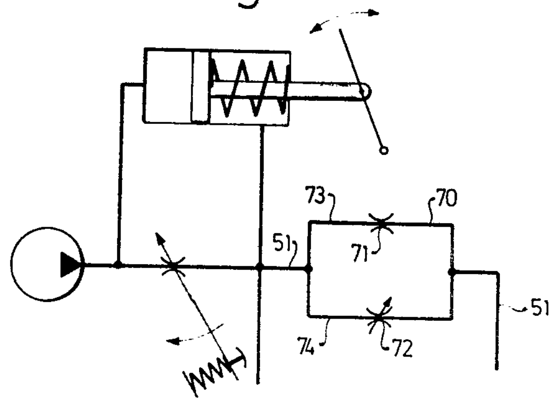
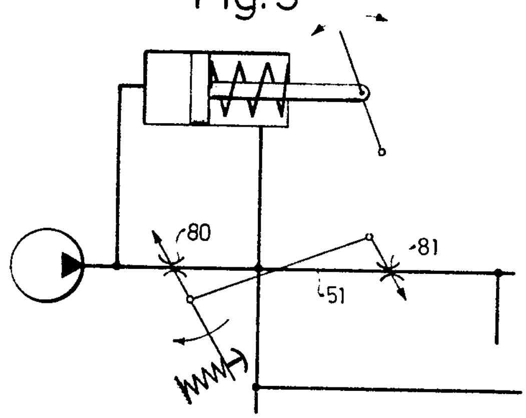


Fig. 3

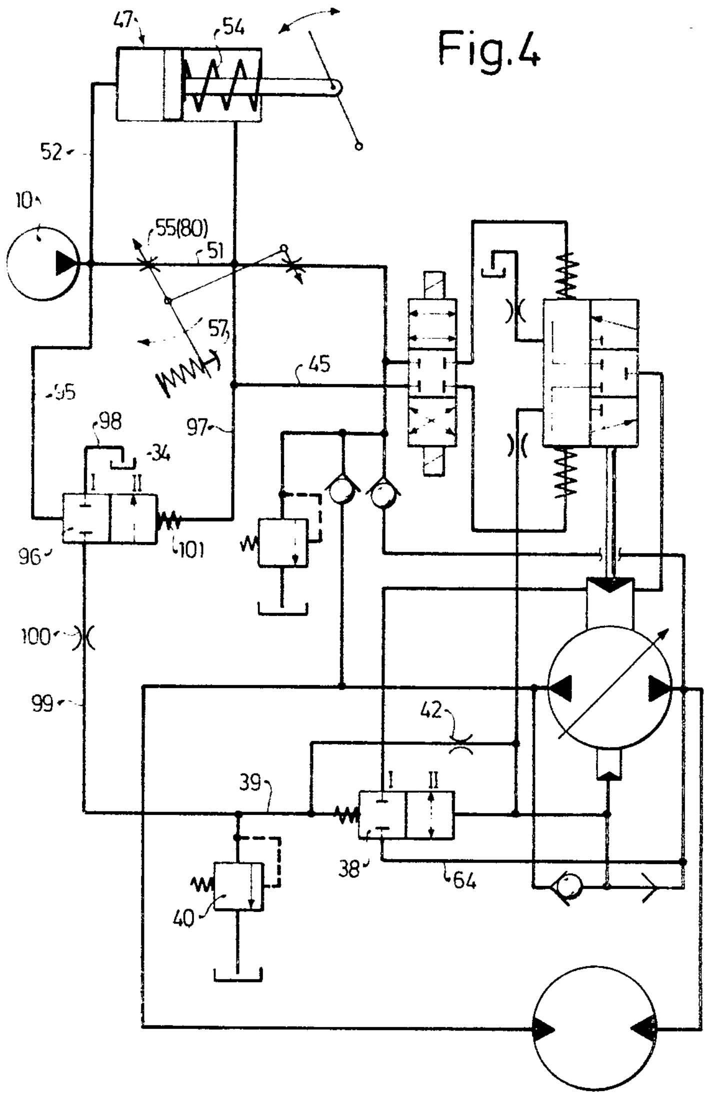


1602628 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

Fig.4



1602628 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 4

Fig.5

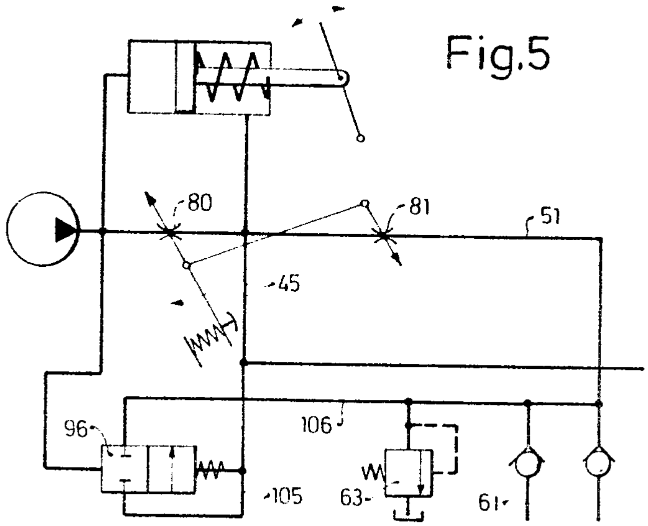


Fig.6